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Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations

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This protocol determines the daily VOC emission rate (pounds of VOC per gallon of coating solids deposited) for a complete automobile and light-duty truck topcoat operation. The protocol is designed for use in cases where (1) the topcoat emission limit is stated in units of pounds of VOC per gallon of solids deposited, (2) compliance is to be demonstrated for each day, and (3) the entire topcoat operation (i.e., all spray booths, flash-off areas and bake ovens where topcoat is applied, dried, and cured; except final off-line repair) is treated as a single entity.

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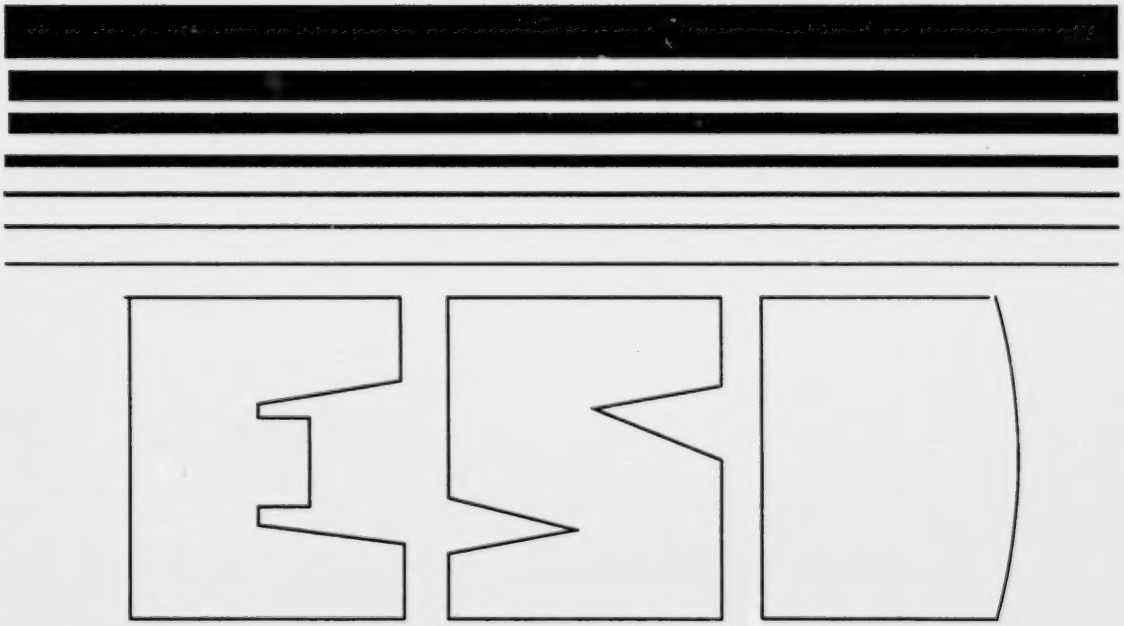

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Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations

Emission Standards Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

December 1988

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1 - INTRODUCTION

This protocol determines the daily VOC emission rate (pounds of VOC per gallon of coating solids deposited) for a complete automobile and light-duty truck topcoat operation. The protocol considers the following factors:

-Daily usage of each coating
-VOC generated per gallon of each coating used
-Volume solids content of each coating used
-Daily weighted transfer efficiency of each coating used
-Daily weighted bake oven exhaust control credit

The protocol describes how to determine each of these factors, including the necessary testing and recordkeeping.

The protocol is designed for use in cases where (1) the topcoat emission limit is stated in units of pounds of VOC per gallon of solids deposited, (2) compliance is to be demonstrated for each day, and (3) the entire topcoat operation (i.e., all spray booths, flash-off areas and bake ovens where topcoat is applied, dried, and cured; except final off-line repair) is treated as a single entity.

The protocol uses the number of square feet coated on each vehicle in each booth with each coating as the basis for the daily weighting of individual transfer efficiency and bake oven exhaust control values. These data are also used to prorate the total usage of each coating in a month to each of the production days in that month. This can be done in lieu of directly monitoring and recording the usage of each category each day. Therefore, the emission rate for each day in a month is calculated at the end of that month.

Sample information sheets and calculations are provided in Appendix A. Use of these sample sheets is not required by the protocol. Alternative data presentation formats may be chosen by the owner/operator. A schematic drawing of the sample coating line used in the examples is presented in Figure 1. Some notes on the sample coating line are presented in Figure 2.

The protocol is intended as a living document which will be improved as experience is gained with its use. The protocol is divided into small sections which are amenable to changes, addition of new sections and incorporation into computer programs. The equations are presented in a form that is amenable to incorporation into computer programs. In some equations, asterisks ("*") are used to indicate multiplication and slashes ("/") are used to indicate division. The protocol as presented here is complete and must be used in its current form for compliance determinations.

In using the protocol, the owner/operator must initially identify various test conditions and parameters, data collection procedures and data presentation formats. For example, the owner/operator needs to choose the spray booths and coatings for transfer efficiency test (Sections 18 and 19) and a method of accounting for coating withdrawals (Section 25). These choices are subject to review by the appropriate regulatory agency(ies). The owner/operator should therefore discuss these choices with the agency(ies) before tests are performed or data are collected. Pre-test review, which is a requirement of many regulations and permits, provides an opportunity to identify and resolve potential issues in advance and thereby minimize the chances of later questions about the representativeness or validity of data and the need for retesting or redesign of data collection procedures or data presentation formats.

The protocol was originally published on June 10, 1988. This printing includes changes and additions made in November and December of 1988. The changes and additions are summarized in Appendix B.

2 - DEFINITIONS

Formulation Solvent Content - The weight of photochemically reactive organic solvents in a specific volume of coating (pounds per gallon) as determined using the procedures in Sections 11, 31, and 32. Volatile by-products of cross-linking reactions (cure volatiles) are not included in the formulation solvent content.

Mix Tank - A coating reservoir which is connected to the circulating system which delivers coating to the coating application equipment. Coating and dilution solvent are added to the circulating system through a mix tank. If the circulating system is kept full, changes in the coating level in a mix tank provide useful information for determining the volume of coating used over a period of time. Totes are mix tanks when they are plugged directly into the circulating system.

VOC Generated - The amount of VOC released from an as applied coating under specific application conditions, including cure volatiles released from those coating solids which are cured in a bake oven, and recognizing that cure volatiles are not released from coatings solids which are not cured in a bake oven. (i.e. overspray coating solids)

3 - SYMBOLS

Variables

BRFRAC(M,N) - Fraction of the total square footage coated on day N that is coated in spray booth M and baked in oven M. These are the bottom row fractions in the daily vehicle coating summary for day N (decimal fraction)

BTE(I,M) - Transfer efficiency for coating I in booth M (decimal fraction)

CA(I,J) - Analytical VOC content of the batch of coating I used in addition J (pounds of VOC per gallon)

CDE(M) - Efficiency of control device which treats exhaust from bake oven M (decimal fraction)

CDL(I,M) - VOC loading from coating I to control device which treats exhaust from bake oven M (pounds of VOC per gallon of solids deposited)

CF(I,J) - Formulation solvent content of the batch of coating I used in addition J (pounds of solvent per gallon)

CFRAC(I,M,N) - Fraction of total square footage coated in booth M on day N that is coated with coating I. These are the fractions in the column for booth M coating summary for day N (decimal fraction)

CP(I) - Volume of coating I that is captured by the purge capture system in a single purge cycle.

DAYSQFT(I,N) - Total square footage coated with coating I on day N (square feet)

DCC(N) - Total bake oven exhaust control credit for day N (pounds of VOC per gallon of solids deposited)

DENS(I,J) - Density of the batch of coating I used in addition J (pounds per gallon)

DER(N) - Daily emission rate for the topcoat operation on day N (pounds of VOC per gallon of solids deposited)

DSD(N) - Total volume of solids deposited on day N (gallons)

DVG(N) - Total mass of VOC generated on day N (pounds)

DVOL (I,J,A) - Density of the volatiles in ingredient A of the batch of coating I used in addition J (pounds per gallon)

END(I) - Volume level of coating I in mix tank at end of month (gallons)

GDAY(I,N) - Volume of coating I used on day N (gallons)

GMON(I) - Volume of coating I used in the month (gallons)

MONSQFT(I) - Square footage coated with coating I in the month (square feet)

NPURGE(I,N) - Number of purge cycles of coating I on day N

PADD(I,J) - Volume of coating I added to mix tank in addition J (gallons)

RADD(I,K) - Volume of dilution solvent added to the mix tank for coating I in addition K (gallons)

RCA(I) - Analytical VOC content of coating I (pounds of VOC per gallon, as applied)

RCF(I) - Formulation solvent content of coating I (pounds of solvent per gallon as applied)

RCV(I,N) - VOC generated per gallon of coating I on day N (pounds of VOC per gallon, as applied)

RD(I,K) - Density of dilution solvent added to the mix tank for coating I in addition K (pounds per gallon)

RVS(I) - Formulation volume solids content of coating I, as applied (decimal fraction)

RFRAC(I,M,N) - Fraction of total square footage coated with coating I on day N that is coated in booth M. These are the fractions in the row for coating I in the daily vehicle coating summary for day N (decimal fraction)

START(I) - Volume level of coating I in mix tank at start of month (gallons)

TCDL(M,N) - VOC loading to control device which treats exhaust from bake oven M weighed for day N (pounds of VOC per gallon of solids deposited)

TCP(I,N) - Total volume of coating I which is captured by purge capture system on day N (gallons)

TE(I,N) - Transfer efficiency for coating I on day N (decimal fraction)

VFS (I,J,A) - Volume solids content of ingredient A added to the batch of coating I used in addition J (decimal fraction)

VOL (I,J,A) - Volume of ingredient A added to the batch of coating I used in addition J (gallons)

VS(I,J) - Formulation volume solids content of the batch of coating I used in addition J (decimal fraction)

WITH(I,P) - Volume of coating I removed from mix tank for coating I in withdrawal P (gallons)

WITHTOT(I) - Total volume of coating I removed from mix tank for coating I in the month (gallons)

WT (I,J,A) - Mass of ingredient A added to the batch of coating I used in addition J (pounds)

WTFRSV (I,J) - Formulation weight fraction solvent content of the batch of coating I used in addition J (decimal fraction)

WTNR (I,J,A) - Weight fraction water or exempt solvent in ingredient A added to the batch of coating I used in addition J (decimal fraction)

WTSOLV (I,J,A) - Weight fraction solvent content of ingredient A added to the batch of coating I used in addition J (decimal fraction)

WTVOL (I,J,A) - Weight fraction volatiles content of ingredient A added to the batch of coating I used in addition J (decimal fraction)

Indices, Counters, Limits

A	Ingredient index for formulation calculations
B	Number of ingredients in the formula for a coating
BC	Base Coat
CC	Clear Coat
I	Coating Index
J	Coating Addition Index
K	Dilution Solvent Addition Index
L(I)	Number of Additions of Coating I in Month
M	Booth or Oven Index
N	Day Index
P	Withdrawal Index
R(I)	Number of Additions of Dilution Solvent to Mix Tank for Coating I in Month
S(I)	Number of Withdrawals from Mix Tank for Coating I in Month
T	Number of Booths/Ovens in Topcoat Operation
V	Number of Coatings Used
W	Number of (Operating) Days in Month
Y	Month Index

4 - DAILY VOC EMISSION RATE CALCULATION

The daily VOC emission rate is calculated by dividing the total pounds of VOC generated that day by the total gallons of solids deposited that day and then subtracting that day's bake oven exhaust control credit.

On day N, the daily emission rate is:

DER(N) = [DVG(N) / DSD(N)] - DCC(N)

A sample calculation is presented in Figure 20.

5 - TOTAL DAILY VOC GENERATED

The total VOC generated each day is calculated by multiplying the volume of each coating used that day by the pounds of VOC generated per gallon of that coating and summing the results.

The VOC generated on day N is:

$$DVG(N) = \sum_{I=1}^{V} [GDAY(I,N) * RCV(I,N)]$$

A sample calculation is presented in Figure 16.

6 - TOTAL DAILY SOLIDS DEPOSITED

The total gallons of solids deposited each day is calculated by multiplying the volume of each coating used that day by its formulation volume solids content and by its daily transfer efficiency and summing the results

The solids deposited on day N are:

$$DSD(N) = \sum_{I=1}^{V} [GDAY(I,N) * RVS(I) * TE(I,N)]$$

A sample calculation is presented in Figure 17.

7 - TOTAL DAILY BAKE OVEN EXHAUST CONTROL CREDIT

The bake oven exhaust control credit is determined for each day by weighting together the individual bake oven control device VOC loading values for that day and the previously determined incinerator efficiencies. The daily weighting factors are the fractions of the total square footage coated that day that are coated in the spray booth associated with each bake oven. These weighting factors are the bottom row fractions in the daily vehicle coating summary.

The bake oven exhaust control credit on day N is:

$$DCC(N) = \sum_{M=1}^{T} [TCDL(M,N) * CDE(M) * BRFRAC(M,N)]$$

A sample calculation is presented in Figure 19.

8 - DAILY COATING USAGE

The volume of each coating used each day can be calculated by prorating the volume of that coating used in a month to each day in the month. The prorating factor is the ratio of the total square footage coated with that coating on the day to the total square footage coated with that coating in the month.

The volume of each coating used on day N is:

GDAY(I,N) = GMON(I) * DAYSQFT(I,N) / MONSQFT(I)

A sample calculation is presented in Figure 14.

If the owner/operator chooses to make an adjustment for captured purge coating, then TCP(I,N) should be subtracted from the above result.

The owner/operator may elect to determine the daily usage of a coating directly by measuring the start-of-day and end-of-day volume of the coating in its mix tank, additions of the coating or dilution solvent to the mix tank, and withdrawals of coating from the mix tank. The daily usage is equal to:

STARTDAY - ENDDAY + ADDITIONS - WITHDRAWALS

9 - DAILY CALCULATION OF VOC GENERATED PER GALLON OF EACH COATING USED

The amount of VOC generated per gallon of each coating used is calculated each day using the analytical VOC content of the as applied coating, formulation solvent content of the as applied coating and the daily transfer efficiency for that coating.

The amount of VOC generated per gallon of coating I used on day N is:

$$RCV(I,N) = RCF(I) * [1 - TE(I,N)] + RCA(I) * TE(I,N)$$

A sample calculation is presented in Figure 15.

10 - ANALYTICAL VOC CONTENT OF AS APPLIED COATING

The analytical VOC content of an as applied coating can be calculated from records on the additions of coating and dilution solvents to that coating's mix tanks during the month.

For each addition of coating, the following information is needed:

- Gallons of coating added
- Analytical VOC content by EPA Method 24 (pounds by VOC per gallon) of the production batch from which the addition was made

For each addition of dilution solvent, the following information is needed.

- Gallons added
- Density (pounds per gallon)

The owner/operator may elect to have the EPA Method 24 analysis performed by the coating supplier or manufacturer. The owner/operator may elect to have the dilution solvent density value provided by the solvent supplier or manufacturer. All other information should be available from the owner/operator records of additions of coating and dilution solvent to mix tanks. Sample records are presented in Figure 11.

At the option of the owner/operator, a fixed (maximum) analytical VOC content value can be used for each coating as long as the use of such values does not underpredict the emission rate of the topcoat operation.

The analytical VOC content of the as applied coating I (pounds of VOC per gallon of coating) is equal to:

$$RCA(I) = \frac{\sum_{J=1}^{L(I)} [PADD(I,J) * CA(I,J)] + \sum_{K=1}^{R(I)} [RADD(I,K) * RD(I,K)]}{\sum_{J=1}^{L(I)} PADD(I,J) + \sum_{K=1}^{R(I)} RADD(I,K)}$$

A sample calculation is presented in Figure 13.

For waterborne coatings, if the precision adjustment factors in Reference Method 24 are used by the enforcing agency, the resulting analytical VOC content should never be less than the formulation solvent content. If the adjusted analytical VOC content is less than the formulation solvent content, then the analytical VOC content should be set equal to the formulation solvent content. That is:

If CA(I,J) LESS THAN CF(I,J) THEN CA(I,J) = CF(I,J)

11 - FORMULATION SOLVENT CONTENT OF AN AS APPLIED COATING

The formulation solvent content of an as applied coating can be calculated from records on the additions of coating and dilution solvents to that coating's mix tanks during the month.

For each addition of coating, the following information is needed:

- Gallons of coating added
- Formulation solvent content (pounds of solvent per gallon) of the production batch from which the addition of as supplied coating was made.

For each addition of dilution solvent, the following information is needed:

- Gallons added
- Density (pounds per gallon)

The owner/operator should obtain formulation solvent content data for the as supplied coating from the coating supplier or manufacturer. These data should be generated using the procedures described in Sections 31 and 32. The owner/operator may elect to have the dilution solvent density value provided by the solvent supplier or manufacturer. All other information should be available from the owner/operator records of additions of coating and dilution solvent to mix tanks. Sample records are presented in Figure 11.

At the option of the owner/operator, a fixed (maximum) formulation solvent value can be used for each coating as long as the use of such values does not underpredict the emission rate of the topcoat operation.

The formulation solvent content of the as applied coating I (pounds of VOC per gallon of coating) is equal to:

$$RCF(I) = \frac{\sum_{J=1}^{L(I)} [PADD(I,J) * CF(I,J)] + \sum_{K=1}^{R(I)} [RADD(I,K) * RD(I,K)]}{\sum_{J=1}^{L(I)} PADD(I,J) + \sum_{K=1}^{R(I)} RADD(I,K)}$$

12 - FORMULATION VOLUME SOLIDS CONTENT OF AS APPLIED COATINGS

The formulation volume solids content of an as applied coating can be calculated from records on the addition of coating and dilution solvents to that coating's mix tanks during the month.

For each addition of coating, the following information is needed:

- Gallons of coating added
- Formulation volume solids content of the production batch from which the addition of as supplied coating was made.

For each addition of dilution solvent, the following information is needed:

- Gallons added

The owner/operator should obtain formulation volume solids content data for the as supplied coating from the coating supplier or manufacturer. These data should be generated using the procedure in Section 33. All other information should be available from the owner/operator records of additions of coating and dilution solvent to mix tanks. Sample records are presented in Figure 11.

At the option of the owner/operator, a fixed (minimum) formulation volume solids value can be used for each coating as long as the use of such values does not underpredict the emission rate of the topcoat operation.

The volume solids content of the as applied coating I is equal to:

$$RVS(I) = \frac{\sum_{J=1}^{L(I)} [PADD(I,J) * VS(I,J)]}{\sum_{J=1}^{L(I)} PADD(I,J) + \sum_{K=1}^{R(I)} RADD(I,K)}$$

13 - DAILY TRANSFER EFFICIENCY

For each coating transfer efficiency shall be determined each day by weighting together the previously determined individual booth transfer efficiencies for that coating. The individual booth transfer efficiencies are the values for individual booths [or groups (parallel and/or series) of booths] determined by the procedures in Sections 18, 19 and 20. The daily weighting factors for each coating are the fractions of the total square footage coated with that coating that day that are coated in each booth [or group of booths] in which that coating is used. These weighting factors are the coating row fractions in the daily vehicle coating summary. These weighting factors provide the relative amount of solids deposited in each booth. An example calculation is presented in Figure 10.

The daily transfer efficiency for each coating is calculated by the following equation.

$$TE(I,N) = \frac{1}{\sum_{M=1}^{T} [RFRAC(I,M) / BTE(I,M)]}$$

Note that since the weighting factors give the relative amount of solids deposited in each booth, dividing a weighting factor by the appropriate transfer efficiency tells the amount of solids sprayed.

14 - DAILY INDIVIDUAL BAKE OVEN CONTROL DEVICE VOC LOADING VALUES

Bake oven exhaust control device VOC loading values are determined each day for each bake oven which is vented to a VOC control device by weighting together the previously determined coating specific bake oven control device VOC loading values for each coating used in the spray booth(s) associated with that bake oven. The weighting factors are the fractions of the total square footage coated that day in the spray booth(s) associated with the bake oven that were coated with each coating used in that spray booth(s).

$$TCDL(M,N) = \sum_{I=1}^{V} [CDL(I,M) * CFRAC(I,M,N)]$$

A sample calculation is presented in Figure 18.

As an alternative, the source owner or operator may choose to set

$$TCDL(M,N) = \min_{I=1}^{V} CDL(I,M)$$

15 - MONTHLY VEHICLE COATING SUMMARY

For each month, calculate the total number of square feet coated with each coating. These values can be calculated by summing the daily totals from the daily vehicle coating summary for each day in the month. If the owner/operator elects in Section 16 to use equivalent vehicles instead of square feet, then equivalent vehicles should be used in this Section too.

$$MONSQFT(I) = \sum_{N=1}^{W} DAYSQFT(I,N)$$

A sample monthly vehicle coating summary is shown in Figure 5.

16 - DAILY VEHICLE COATING SUMMARY

The coatings used and the number of square feet coated with each coating in each spray booth are determined daily. The square foot figures are determined from the specifications for each type or style of vehicle coated.

For each day, the total square feet coated with each coating in each booth is calculated. The fraction of the total square feet coated in each booth that is done with each coating and the fraction of the total square feet coated with each coating that is done in each booth are also calculated each day. These two items are the coating column fractions (CFRAC) and coating row fractions (RFRAC) in the daily vehicle coating summary. The fraction of the total square feet coated each day that is done in each booth is also calculated. This is the bottom row fraction in the (BRFRAC) daily vehicle coating summary. A sample daily vehicle coating summary is shown in Figure 4.

The owner/operator may elect to substitute "equivalent vehicles", and appropriate documented fractions thereof, for square footage values. Equivalent vehicle means a typical vehicle selected as the basis for equating an increase or decrease in the fractional size of all other vehicles or portions of vehicles coated in a particular topcoat operation calculated to the nearest 0.01 vehicle. A sample equivalent vehicle calculation is presented in Figure 22.

The owner/operator may elect to set the daily number of square feet of in-line repair work done with each coating equal to 4 percent of total square footage (excluding in-line repair) coated with that coating on that day. A sample calculation is presented in Figure 23.

A sample of the information needed for each vehicle processed is provided in Figure 3. The owner/operator may elect to record this information or just use this information to create running daily totals for the daily vehicle coating summary.

17 - MONTHLY COATING USAGE

The monthly usage of each as applied coating can be determined from the start-of-month and end-of-month volume of that coating in its mix tank, records of additions of coating and dilution solvent to the mix tank, and records of withdrawals of coating from the mix tank.

The following equation can be used to determine the monthly usage of an as applied coating.

$$GMON(I) = START(I) - END(I) + \sum_{J=1}^{L(I)} PADD(I,J) + \sum_{K=1}^{R(I)} RADD(I,J)$$

$$\ldots - \sum_{P=1}^{S(I)} WITH(I,P)$$

A sample calculation is presented in Figure 12.

18 - TRANSFER EFFICIENCY TEST PROCEDURE - IN PLANT

Applicability

This procedure can be used to determine by in-plant testing the transfer efficiency with which specific coatings are applied in an automobile or light-duty truck topcoat operation. The transfer efficiency of color and clear coats applied in main color booth(s) must be determined with this method or with the pilot line test method described in Section 19. The choice of in-plant or pilot line test is made by the owner/operator. At the option of the owner/operator, the transfer efficiency of other coatings applied in main color booth(s) (e.g., blackout) and coatings applied in other booths (e.g., separate "interior" color booth, tutone or in-line repair) may be determined by this procedure, by the pilot line test procedure described in Section 19, or by the alternate procedure described in Section 20 (Alternate Transfer Efficiency Procedure for Untested Booths and/or Coatings). The results determined by this procedure, the pilot line test procedure described in Section 19, and the alternate procedure described in Section 20 are combined for each coating each day in the Daily Transfer Efficiency Values section (Section 13).

Scope

This procedure for transfer efficiency uses the measured weight of coating solids applied to vehicles or foiled vehicles in production facilities.

Transfer Efficiency Procedure

A. The owner/operator selects the spray booth(s) to be included in the test. A main color booth must be included in the test. Each identical parallel booth in the same assembly line need not be tested.

B. The owner/operator selects the coatings to be used in the test. This procedure can be run for each coating used, but it is not necessary to test every coating. The coatings may be grouped based on processing sequence. Only one coating need be tested from each group and the result used for all of the coatings in that group. Some sample groupings are straight shades, non-metallic basecoats, metallic basecoats, mica basecoats and clear coats. These sample groupings are not the only possible groupings. Others may be appropriate based on processing sequence (e.g., the processing sequence for metallic basecoats and mica basecoats may be the same or silver basecoat may be applied with only air spray while all other metallic basecoats are applied with air spray and electrostatic spray). The owner/operator must explain in the test report the groupings used and the rationale for choosing a particular coating from each group for testing. To simplify testing and more closely represent actual process conditions, basecoat and clear coat can be tested together at the owner/operator option as noted later in this procedure.

C. Select an area in the facility for the body weighing or foil weighing which has relatively constant temperature and minimal air movement.

D. Topcoat must be the only coating applied during the test. If the body is weighed, weight loss from all other materials must be accounted for in the initial test weight.

E. A minimum of two foiled or unfoiled vehicle bodies (or major subassemblies thereof) are to be weighed to determine weight of solids applied. The test is considered acceptable if each final weight gain result is within 10 percent of the average weight gain.

F. Identify and preweigh vehicle bodies or major subassemblies to be painted to the nearest 0.05 lb. If foil method is used preweigh all available foil and tape. After vehicle is foiled, reweigh all unused foil and tape to determine beginning weight of test foil and tape by difference.

G. Isolate selected paint material at each spray station by using an auxiliary paint system or paint pots. Alternatively, at the owner/operator option, coating usage may be measured from the main circulating system tanks.

H. At the owner/operator option, determination of the amount of material used during the test may be made by weight or volumetric measurement as follows:

Weight Measurement

1. Weigh the tank of reduced paint after all supply and return lines have been filled, to nearest 0.05 lb.

2. Connect the paint tank to the system and paint the test vehicles or targets.

3. Reweigh the tank to nearest 0.05 lb.

4. Determine weight of paint material used by subtracting final weight of tank from the initial weight of tank.

5. Obtain paint samples for weight solids determination.

6. The initial and final weighings of the paint tank must both be done with the tank pressurized or both be done with the tank not pressurized.

Volume Measurement

1. a. Verify diameter of paint tank.

   b. Determine level in paint circulating tank prior to test, to nearest 0.1 inch.

2. Paint the test vehicles or targets. (It is suggested that the number of units painted should be chosen to achieve approximately a 3" to 4" drop in a typical circulating tank.)

3. Determine the paint level after the test to the nearest 0.1 inch.

   Paint usage from a cylindrical tank is determined as follows:

$$\frac{\text{Gallons Paint Used}}{\text{job}} = \frac{\pi r^2 h}{231n} - \text{Volume occupied by all other equipment in the measured section of the tank.}$$

   231 = Cubic inches per gallon

   π = 3.1416

r = Radius of tank in inches

h = Drop of paint level in tank in inches

n = Number of vehicle bodies or major subassemblies painted to achieve the measured liquid level drop in circulating tank

4. Obtain paint samples for testing weight solids fraction and coating density.

J. Reweigh the painted test vehicles, foil or components to the nearest 0.05 lb after paint has cured, and cooled.

K. Determine the weight solids of the paint samples using ASTM-D 2369-86.

L. Determine the coating density using ASTM-D 1475 (lb/gallon).

M. The transfer efficiency is calculated by dividing the weight of paint solids applied to the vehicle or foil by the weight of paint solids used.

Calculation for Paint Usage by Weight

$$\text{Transfer Efficiency} = \frac{\text{average weight gain of target}}{(\text{average weight coating consumed per job}) \times (\text{weight fraction solids})^*}$$

Calculation for Paint Usage by Volume

$$\text{Transfer Efficiency} = \frac{\text{average weight gain of target}}{(\text{average gallons coating used per job}) \times (\text{density}) \times (\text{weight fraction solids})^*}$$

The test result for coating I in booth M is referred to in the section on Daily Transfer Efficiency as BTE(I,M).

* If more than one coating is sprayed on each test vehicle (e.g. basecoat and clear coat), then the denominator is the sum of all solids sprayed.

General Comments

At the owner/operator option, separate transfer efficiency values for BC and CC can be determined directly by coating at least two vehicles with BC only and at least two vehicles with BC/CC. The average weight gain per job for CC only can be determined by subtracting the average weight gain per job for BC only from the average weight gain per job for BC/CC.

Frequency of Certification

Transfer efficiency tests must be conducted for an initial compliance test. The owner/operator must review the operating conditions annually thereafter. The most recent test results remain valid as long as the owner/operator demonstrates that no significant changes have occurred in paint technology or processing. Significant product, processing, material or application equipment changes will necessitate reevaluation of the transfer efficiency of the operations which have been modified. Such complete reevaluation must be done as soon as practicable (not later than 180 days after start-up) after start-up and stabilization of the new product, process, material or application equipment. The results of this reevaluation (i.e., new transfer efficiency values) must be used retroactively to the start-up of the new product, process, material or application equipment. Reevaluation is not necessary for:

A. Model year product changes, unless there are significant changes in size and shape of the typical vehicle.

B. Processing and material changes such as new model year or special order colors of the same formula type, minor changes in line rate, minor changes in processing sequence, minor changes in equipment types, etc.

19 - TRANSFER EFFICIENCY TEST PROCEDURE - PILOT LINE

A - Applicability

This procedure can be used to determine by pilot line testing the transfer efficiency with which specific coatings are applied in an automobile or light-duty truck topcoat operation. The transfer efficiency of color and clear coats applied in main color booth(s) must be determined with this method or with the in plant test method described in Section 18. The choice of in-plant or pilot line test is made by the owner/operator. At the option of the owner/operator, the transfer efficiency of other coatings applied in main color booth(s) (e.g., blackout) and coatings applied in other booths (e.g., separate "interior" color booth, tutone or in-line repair) may be determined by this procedure, by the in-plant test procedure described in Section 18, or by the alternate procedure described in Section 20 (Alternate Transfer Efficiency Procedure for Untested Booths and/or Coatings). The results determined by this procedure, the in-plant test procedure described in Section 18, and the alternate procedure described in Section 20 are combined for each coating each day in the Daily Transfer Efficiency Values section (Section 13).

B - Scope

This procedure for transfer efficiency uses the measured weight of coating solids applied to vehicles or foiled vehicles in pilot line facilities. The production line process is simulated in the pilot line. The pilot line data are validated against production line data to verify that a credible simulation has been carried out. Once the pilot line data have been validated, the pilot TE results are adjusted to improve the correlation with production line data.

C - Selection of Spray Booth(s) and Coating(s) to be Tested

1. The owner/operator selects the production spray booth(s) to be simulated in the pilot line test. Each identical parallel booth in the same assembly line need not be simulated separately.

2. The owner/operator selects the coatings to be used in the test. This procedure can be run for each coating used, but it is not necessary to test every coating. The coatings may be grouped by the owner/operator based on processing sequence. Only one coating need be tested from each group and the result used for all of the coatings in that group. Some sample groupings are straight shades, non-metallic basecoats, metallic basecoats, mica basecoats and clear coats. These sample groupings are not the only possible groupings. Others may be appropriate based on processing sequence (e.g., the sequence for metallic basecoats and mica basecoats may be the same or silver basecoat may be applied with only air spray while all other metallic basecoats are applied with air spray and electrostatic spray). The owner/operator must explain in the test report the groupings used and the rationale for choosing a particular coating from each group for testing. To simplify testing and more closely represent actual process conditions, basecoat and clear coat can be

tested together at the owner/operator option as noted later in this procedure. The coatings used in the pilot test must be coatings that are used in the plant (i.e., same manufacturer, product code and solvent reduction conditions).

D - In-Plant Survey and Data Collection

1. The owner/operator conducts an in-plant survey of the spray booth(s) to be simulated in the test to determine the operating parameters.

The following parameters must be noted:

- Number of spray stations
- Type and number of spray guns at each spray station
- Portion of vehicle coated at each spray station

Additional parameters may be noted at the option of the owner/operator. These additional parameters could include any or all of the following: (Note: The more parameters that are noted in the plant and faithfully reproduced in the pilot line test, the greater the likelihood of the pilot line test producing acceptable results which pass the tests for data validity.)

°Fluid nozzles and tips
°Air pressures at the heel of guns
°Electrostatic voltage settings
°Reciprocator trigger points
°Fluid delivery rate per gun
°Open gun times
°Paint temperature
°Paint viscosity

°Analytical weight solids
°Fan width
°Dry film thickness
°Gun to target distance
°Resistivity of paint
°Line speed adjusted to plant specifications
°Traverse speed (strokes per minute for recips, cycles for bells)
°Contour bar for reciprocators should be designed for vehicle being sprayed
°Booth balance
°Booth downdraft (lfpm)
°Booth temperature
°Booth relative humidity
°Bell RPM
°Bell shaping air
°Bell and recip. angles
°Set zone pressure to those at the process of interest

The in-plant values for each parameter noted must be recorded and presented in the test report. In situations where the coating of interest is applied in two or more "identical" parallel booths, the noted parameters must be measured in at least two of these booths. The individual booth measurements and average measurement must be presented in the test report.

2. For each coating to be tested, the owner/operator determines the average weight of solids sprayed per vehicle in the production booth(s) to be simulated. This is to be done either by determining the average mass of coating used per vehicle and multiplying by the analytical weight solids content, or by determining the average volume of coating used per vehicle and multiplying by the analytical coating density and by the analytical weight solids content.

The average mass or volume of coating used per vehicle may be determined from usage on a block of vehicles as in the in-plant TE test, from direct measurements (e.g., use of temporary in-line meters), or from gun on times and fluid flow rates. (See Parts L-7 and L-8 of this section.) In situations where the coating of interest is applied in two or more "identical" parallel booths, coating usage per vehicle must be determined using data from at least two of these booths.

3. For each coating to be tested, the owner/operator determines the average in-plant dry film build for Class I and Class II areas. This is to be done by taking before and after dry film build measurements on at least two vehicles. (See Part L-6 of this section). At least one before and after dry film build measurement must be made for each square foot of Class I surface area coated per vehicle. These measurements must be uniformly distributed over the Class I area of the vehicle, with the same distribution used for before and after measurements. At least two before and after dry film build measurements must be made for each square foot of Class II surface area coated per vehicle. [Large flat interior panels (e.g., interior of commercial panel vans) may be treated as Class I area for dry film build measurements.] These measurements must be uniformly distributed over the Class II area of the vehicle, with the same distribution used for before and after measurements. (See Part L-5 of this section.) In situations where the coating of interest is applied in two or more "identical" parallel booths, the vehicles on which the film build measurements are made must be coated in at least two of these booths.

4. The owner/operator calculates the overall average dry film build by weighting together the average Class I and Class II film builds by the square feet of Class I and Class II area coated per vehicle.

E - Pilot Line Set-Up

1. Select an area in the pilot facility for the body weighing or foil weighing which has relatively constant temperature and minimal air movement.

2. Topcoat must be the only coating applied during the test. If the body is weighed, weignt loss from all other materials must be accounted for in the initial test weight.

3. Prepare the pilot line to simulate the in-plant conditions. The pilot line must use the same number of spray stations or steps as there are in-plant. At each station the same type and number of gun(s) must be used and the same portions of the vehicle must be coated. Additional parameters, documented in-plant are set in the pilot. The pilot line values for each parameter that was documented in-plant must be recorded and presented in the test report. Portions of the vehicle which are not designated for coating in-plant must not be coated to a greater extent in the pilot facility than they are coated in-plant (i.e., overspray that unavoidably lands in these areas in plant is acceptable in pilot, but intentional excess coating of undesignated areas in the pilot test is not acceptable).

F - Pilot Line Test

1. A minimum of two foiled or unfoiled vehicle bodies (or major subassemblies thereof) are to be weighed to determine weight of solids applied. The test is considered potentially acceptable, subject to pilot line data validation, if each final weight gain result is within 10 percent of the average weight gain.

2. Identify and preweigh vehicle bodies or major subassemblies to be painted to the nearest 0.05 lb. If foil method is used preweigh all available foil and tape. After vehicle is foiled, reweigh all unused foil and tape to determine beginning weight of test foil and tape by difference.

3. Isolate selected paint material at each spray station by using an auxiliary paint system or paint pots. Alternatively, at the owner/operator option, coating usage may be measured from the main circulating system tanks.

4. At the owner/operator option, determination of the amount of material used during the test may be made by weight or volumetric measurement as follows:

Weight Measurement

i. Weigh the tank of reduced paint after all supply and return lines have been filled, to nearest 0.05 lb.

ii. Connect the paint tank to the system and paint the test vehicles or targets.

iii. Reweigh the tank to nearest 0.05 lb.

iv. Determine weight of paint material used by subtracting final weight of tank from the initial weight of tank.

v. Obtain paint samples for weight solids determination.

vi. The initial and final weighings of the paint tank must both be done with the tank pressurized or both be done with the tank not pressurized.

Volume Measurement

i. a. Verify diameter of paint tank.

b. Determine level in paint circulating tank prior to test, to nearest 0.1 inch.

ii. Paint the test vehicles or targets. (It is suggested that the number of units painted should be chosen to achieve approximately a 3" to 4" drop in a typical circulating tank.)

iii. Determine the paint level after the test to the nearest 0.1 inch.

Paint usage from a cylindrical tank is determined as follows:

$$\frac{\text{Gallons Paint Used}}{\text{job}} = \frac{\pi r^2 h}{231n} - \text{Volume occupied by all other equipment in the measured section of the tank.}$$

231 = Cubic inches per gallon

π = 3.1416

r = Radius of tank in inches

h = Drop of paint level in tank in inches

n = Number of vehicle bodies or major subassemblies painted to achieve the measured liquid level drop in circulating tank

iv. Obtain paint samples for testing weight solids fraction and coating density.

5. Reweigh the painted test vehicles, foil or components to the nearest 0.05 lb after paint has cured, and cooled.

6. Determine the weight solids of the paint samples using ASTM-D 2369-86.

7. Determine the coating density using ASTM-D 1475 (lb/gallon).

8. For each coating tested, determine the average weight of solids sprayed per vehicle in the pilot test. This is done either by multiplying the average mass of coating used per vehicle by the analytical weight solids content, or by multiplying the average volume of coating used per vehicle by the analytical coating density and by the analytical weight solids content.

9. For each coating tested, the owner/operator determines the average pilot line dry film build for Class I and Class II areas. This is to be done by taking before and after dry film build measurements on at least two vehicles. (See Part L-6 of this section.) At least one before and after dry film measurement must be made for each square foot of Class I area coated per vehicle. At least two before and after dry film build measurements must be made for each square foot of Class II surface area coated per vehicle. The locations for film build measurements must be uniformly distributed over the Class I and Class II areas on vehicle with the same distribution used for before and after measurements. (See part L-5 of this section.)

10. The owner/operator calculates the overall average pilot line dry film build by weighting together the average Class I and Class II film builds by the square feet of Class I and Class II area coated per vehicle.

G - Pilot Line Data Validation

1. All of the following tests must be met (except as described in Part K) in order for the pilot data for a particular coating to be considered valid. If any of the following tests are not met, the pilot data are not valid and cannot be used to calculate in-plant transfer efficiency. (See Figure 24.)

2. The average weight of solids sprayed per vehicle in the pilot test must be within or equal to ± 20 percent of the average weight of solids sprayed per vehicle in-plant.

3. The overall average dry film build in the pilot test must be within or equal to ± 20 percent of the overall average dry film build in-plant.

4. The percent change in weight of solids sprayed per vehicle from plant to pilot and the percent change in overall dry film build from plant to pilot must be within 20 percentage points of each other.

$$\text{If } A = \frac{\text{Solids sprayed pilot - Solids sprayed plant}}{\text{Solids sprayed plant}} * 100$$

$$\text{and } B = \frac{\text{Overall film build pilot - Overall film build plant}}{\text{Overall film build plant}} * 100$$

then the absolute value of A - B must be less than or equal to 20.

H - Calculation of Pilot Line TE

1. If all the pilot line data validation tests are satisfied, then the pilot line TE is calculated by dividing the weight of paint solids applied to the vehicle or foil by the weight of paint solids used.

Calculation for Paint Usage by Weight (See Figure 25.)

$$\text{Pilot Transfer Efficiency} = \frac{\text{average weight gain of target}}{(\text{average weight coating consumed per job}) \times (\text{weight fraction solids})*}$$

Calculation for Paint Usage by Volume

$$\text{Pilot Transfer Efficiency} = \frac{\text{average weight gain of target}}{\text{(average gallons coating used per job) x (density) x (weight fraction solids)*}}$$

*If more than one coating is sprayed on each test vehicle (e.g., basecoat and clear coat), then the denominator is the sum of all solids sprayed.

I - Adjustment of Pilot Line TE

1. The pilot line TE values must be adjusted based on the differences in average weight solids sprayed per vehicle and overall average dry film build between the pilot line and the plant. (See Figure 26.) The adjusted values may be used in the section on Daily Transfer Efficiency. The adjusted pilot line test result for coating I in booth M is referred to as BTE(I,M).

$$BTE(I,M) = \text{Pilot TE} * \frac{\text{Solids sprayed pilot}}{\text{Solids sprayed plant}} * \frac{\text{Overall film build plant}}{\text{Overall film build pilot}}$$

J - Frequency of Certification

1. Transfer efficiency tests must be conducted for an initial compliance test. The owner/operator must review the operation conditions annually thereafter. Significant product, processing, material or application equipment changes will necessitate complete reevaluation of the transfer efficiency of the operations which have been modified. Such complete reevaluation must be done as soon as practicable (not later than 180 days after start-up) after start-up and stabilization of the new product, process, material or application equipment. The result of this reevaluation

(i.e., new transfer efficiency values) must be used retroactively to the start-up of the new product, process, material, or application equipment. Reevaluation is not automatically necessary for:

i. Model year product changes, unless there are significant changes in size and shape of the typical vehicle.

ii. Processing and material changes such as new model year or special order colors of the same formula type, minor changes in line rate, minor changes in processing sequence, minor changes in equipment types, etc.

2. If no significant changes occur over a year, the owner/operator must still revalidate and readjust the pilot test data annually. (See Figure 27.) This is done by conducting an annual in-plant survey of average weight of solids sprayed per vehicle and average Class I and Class II dry film build for each coating previously tested on the pilot line. (These data should be collected in the same manner as in the initial pre-test survey.) The pilot line test data are then revalidated against the new in-plant data as described in Parts G and K of this section. If all the required tests are passed, then the pilot data are still valid and new adjusted TE values are calculated as described in Parts I and K of this section. If the pilot data are no longer valid, then a new TE test must be conducted. (Note: If a coating that was used in the most recent pilot test is no longer used in-plant, then the annual revalidation and readjustment may be done using another coating from the same group of coatings.)

3. Similarly, at the owner/operator option, the effect of minor process or product changes on transfer efficiency may be taken into account at

any time without necessarily having to conduct a complete new pilot line test. This may be done by following the procedure in part J-2 of this section. If the pilot test data are still valid compared to the new in-plant data, then new adjusted TE values may be calculated without performing a new pilot TE test.

K - General Comments

At the owner/operator option, separate TE values for BC and CC can be determined directly by coating at least two vehicles with BC only and at least two vehicles with BC/CC. The average weight gain per job for CC alone can be determined by subtracting the average weight gain per job for BC only from the average weight gain per job for BC/CC.

The BC only vehicles and the BC/CC vehicles must meet the within 10 percent weight gain tests (Part F-1) for the test to be considered potentially valid, subject to pilot line data validation.

The BC/CC vehicles must pass all the pilot line data validation tests in Part G. The BC only vehicles must pass the test in Part G-2. The BC only vehicles do not have to be assessed with respect to the test in Part G-3, G-4 and G-5 (i.e., there is no need to collect BC only film build data in the plant).

The adjustments to pilot BC and pilot CC TE should be made as follows:

$$BTE(BC,M) = \text{Pilot BC TE} * \frac{\text{BC solids sprayed pilot}}{\text{BC solids sprayed plant}} * \frac{\text{Overall BC/CC film build plant}}{\text{Overall BC/CC film build pilot}}$$

$$BTE(CC,M) = \text{Pilot CC TE} * \frac{\text{CC solids sprayed pilot}}{\text{CC solids sprayed plant}} * \frac{\text{Overall BC/CC film build plant}}{\text{Overall BC/CC film build pilot}}$$

L - Additional Information and Definitions

1. Each dry film build measurement should be performed consistent with ASTM B499-87, "Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals." The number of dry film build measurements should be as specified in parts D-3 and F-9 of this section, rather than as specified in part 6.3.4 of ASTM B499-87.

2. Class I means exterior surfaces designated to be coated that are visible with hood, deck lid and doors closed.

3. Class II means all surfaces designated to be coated that are not Class I.

4. All weight solids determinations must be done with ASTM D2369-86

5. Dry film build measurements are not required to be made on non-magnetic substrates (e.g., plastic parts) for which the magnetic instruments described in ASTM B499-87 cannot be directly used to measure coating thickness if the total designated coated area (Class I plus Class II) of these substrates is less than 25 percent of the total area (Class I plus Class II) coated on the vehicles. The total Class I and total Class II areas coated (including non-magnetic substrate area) must be used to determine the number of Class I and Class II dry film build measurements required and to calculate overall average dry film build. (See Figures 28 and 29.) The dry film build measurements that would normally be made on a particular part, but are not made because the part is constructed of a non-magnetic substrate must be made on a corresponding part. For example, if a vehicle has a 10 square foot Class I plastic front fender and no dry film build measurements are made on that fender, then the

(approximately) 10 measurements that would normally be made on the fender could be made as additional measurements on a rear quarter panel. Other examples of corresponding parts are hood and deck lid, engine compartment and trunk interior, etc.

If 25 percent, or more, of the total area (Class I plus Class II) coated on the vehicle is on non-magnetic substrates, then in-plant and pilot line dry film build measurement are required for the non-magnetic substrates. These measurements can be accomplished by wrapping the non-magnetic substrates with foil or by attaching magnetic basis metal (e.g., steel) shims to the non-magnetic substrates. The film build measurement device must be calibrated for the foil or shims.

6. The requirement to take before and after dry film build measurements on at least two vehicles can be met at the owner/operator option by taking before and after measurements on portions of a greater number of vehicles as long the equivalent of at least two complete vehicles (i.e., two of each panel or surface) is measured.

The before and after measurements for a particular panel or surface must be made on the same vehicle. An example of an equivalent vehicle would be all before and after measurements from front windshield forward on one vehicle, all before and after measurements from front windshield to rear windshield on a second vehicle, and all before and after measurements from the rear windshield back on a third vehicle. The equivalent vehicle approach may be helpful when the owner/operator chooses to perform in-plant dry film build measurements while the vehicles are still in process (e.g., on the conveyor) as opposed to removing the vehicles from the production line.

7. The method used to determine in-plant average mass or volume of coating used per vehicle is chosen by the owner/operator from the options presented in Part D-2 of this section. The in-plant determinations of average mass or volume of coating used per vehicle and Class I and Class II dry film builds must be made contemporaneously. For example, if coating usage per vehicle is determined from usage on a block of vehicles, then the vehicles on which film build measurements are made must be included in that block. If temporary in-line meters or fluid flow rates and gun on times are used to determine coating usage per vehicle for manual guns, the metering or gun on time measurements must include the manual coating of the vehicles on which film build measurements are made. If temporary in-line meters or fluid flow rates and gun on times are used to determine coating usage per vehicle for automatic guns, the metering or gun on time measurements must be done during the same shift in which the automatic coating of the vehicles on which film build measurements are made.

8. If gun on times and fluid flow rates are used to determine in-plant average coating usage per vehicle, caution must be used to account for fluid flow rate variation during the spray cycle of each piece of equipment. This variation could be caused by partial triggering of manual guns or fluid pressure changes in automatic guns.

20 - ALTERNATE TRANSFER EFFICIENCY PROCEDURES FOR UNTESTED BOOTHS AND/OR COATINGS

This section describes an alternate transfer efficiency procedure that may be used for those parts of the topcoat operation whose transfer efficiencies are not determined using the test procedure in either Section 19 or 20. These parts may include color and clear coatings applied in untested booths (e.g. separate "interior" color booth, tutone, or in-line repair); and other coatings applied in tested booths (e.g. blackout applied in a main color booth).

The following predetermined transfer efficiency values may be used by these situations:

Air Atomized Spray	40 percent
Electrostatic Spray	55 percent

If a particular coating is applied with both types of equipment, then the two transfer efficiency values should be weighted by relative square footage coated by each method.

$$\text{Transfer Efficiency} = \frac{1}{\frac{\text{Air Fraction}}{.4} + \frac{\text{Estatic Fraction}}{.55}}$$

Where Air Fraction + Estatic Fraction = 1

The transfer efficiency for coating I in booth M is referred to as BTE(I,M) in the section on Daily Transfer Efficiency.

21 - TEST PROCEDURE FOR DETERMINING BAKE OVEN EXHAUST CONTROL DEVICE VOC LOADING FOR SPECIFIC COATINGS

This procedure is used to determine the bake oven exhaust control device VOC loading for specific solvent-borne coatings used in an automobile or light-duty truck topcoat operation.

Scope

This procedure simulates the loss of VOC from a freshly painted surface by weight difference before and after baking. Metal test panels are subjected to simulated coating film build, flashing and baking sequence. The weight loss during baking is then related to the volume of solids deposited on the test panels to compute a control device inlet loading in pounds VOC per gallon solids applied. Identification of the points at which painted vehicles would enter oven zones whose effluents are vented to a control device provides the data needed to determine the oven VOC loading available for destruction in control device equipped zones.

A baking oven must be used to thoroughly cure the paint film. Gas-fired ovens are more representative of actual production; however, a vented electric oven may be used.

Film thickness is to be measured with an instrument, such as an Elcometer or Dualscope. Ensure that this equipment is capable of measurements on substrate selected if direct measurements on the panels are to be taken.

Process

The processing conditions must be determined prior to beginning the test, including film thicknesses, flash times, and baking sequence, to ensure use of values that represent the range of conditions found in the plant.

Identify all locations in the process sequence in which oven effluent is vented directly to a control device for VOC destruction. This will affect the number of panel weight measurements taken and the number of test panels that need to be run. If more than one oven is vented to a control device then panels need to be run for each different baking sequence and ventilation pattern.

Selection of Coatings for Evaluation

This procedure need not be run for each coating used. The coatings used may be grouped based on similar appearance characteristics, processing sequences and dry film thicknesses. One coating can be tested from each group and the result used for all of the coatings in that group. Some sample groupings are straight shades (colors that do not receive a clear coat), non-metallic basecoats, metallic basecoats, mica basecoats and clear coats. In order to more closely represent actual process conditions, basecoat and clear coat can be tested together at owner/operator option as noted later in the procedure.

For each coating evaluated, run triplicate test panels for each production bake oven which is vented to a control device.

Weight Measurements to be Recorded

Weigh panel before paint is applied (W)

Coat panel according to plant process sequence.

Weigh coated panel at point in bake cycle at which exhaust air is first vented to the incinerator (W1).

Weigh coated panel at point in bake cycle at which exhaust air is no longer vented to the incinerator (W2). (Note: Panel should be cooled to room temperature before weighing).

If W2 does not represent a fully cured coating film, then a duplicate painted panel should remain in the oven to complete the full bake cycle. Cool and weigh this panel (W3). [This weight (W3) should be used to determine the Gallons Solids Applied (GSA), covered later in this section].

Measurement of Film Thickness

Coupons should be coated and baked along with the test panels for measurement of film thicknesses of basecoat and clearcoat on the panels. For straight shade systems, film thickness measurements may be taken directly on the panels.

Dry film thickness measurements should be recorded for basecoat and clearcoat for each panel tested.

Determination of Dry Solids Density

Dry solids density may be calculated as shown below. Information needed to perform this calculation includes the weight fraction solids, volume fraction solids, and gallon weight of the coating materials as applied. These values should be determined using the procedures specified in EPA Method 24. The one-hour bake should be used in the weight fraction solids determination. The formulation volume fraction solids value should be generated using the procedure described in Section 33. Solids density is calculated using the following equation:

$$SD = \frac{WFS \times WGC}{VFS}$$

SD = Solids Density (lbs solids/gal solids)

WFS = Weight Fraction Solids (lbs solids/lbs paint)

WGC = Weight Per Gallon of Coating (lbs paint/gal paint)

VFS = Volume Fraction Solids (gal solids/gal paint)

If base coat and clear coat are applied to the same panel, determine the weighted average paint solids density by the ratio of film thickness as follows:

$$WSD = \frac{T1}{T1 + T2} \times D_{bc} + \frac{T2}{T1 + T2} \times D_{cc}$$

WSD = Weighed Solids Density

T1 = BC Film Thickness

T2 = CC Film Thickness

D_{bc} = BC Solids Density

D_{cc} = CC Solids Density

Calculations

The following calculations are used to express bake oven control device loading in pounds VOC per gallon solids applied (GSA).

Weight of coating solids applied = coated panel weight after full bake minus panel weight before coating application.

WPS = W3 - W or

WPS = W2 - W if W2 represents a fully cured paint film

where WPS = weight of coating solids applied

Weight of VOC available for control equals panel weight at point which all exhaust air is vented to control device minus panel weight at point which exhaust air is no longer vented to the control device.

WSA = W1 - W2

where WSA = weight of VOC available for control

Set up the following ratio for each panel measured:

weight of VOC available for control/weight of paint solids applied

RATIO = WSA/WPS

Convert this ratio to units of pounds VOC available for control per gallon of coating solids applied by multiplication of this ratio by paint solids density.

CDL = RATIO x WSD

where CDL = VOC loading expressed in terms of pounds VOC per gallon solids applied.

WSD = weighted solids density expressed in terms of pounds solids per gallon solids

Frequency of Certification

Bake oven exhaust control device VOC loading must be determined for an initial compliance test. The owner/operator must review the operating conditions annually thereafter. The most recent test results remain valid as long as the owner/operator demonstrates that no significant changes have occurred in coating technology or processing. A significant change in coating technology is considered to be a major difference in the generic nature of the coating chemistry. Annual variations in color palette or routine minor solvent blend adjustments for processing, quality, or other reasons do not constitute significant changes in coating technology. Significant process changes may include changing ducting to the incinerator, or major size modifications to spray booths, flash tunnels, or ovens.

Equipment

Use triplicate aluminum or thin steel panels with a minimum area of 20 square inches for each coating evaluated.

For weight measurements, use a balance with accuracy to 0.001g.

Coating is to be applied in a laboratory spray booth with booth air velocity representative of production conditions.

Coating materials must be the specific formulations (in as-applied condition) as used in the plant whose control device VOC loading is to be determined.

22 - BAKE OVEN EXHAUST CONTROL DEVICE EFFICIENCY

The efficiency of a bake oven exhaust control device (incinerator destruction efficiency) should be determined using the following methods for the inlet and outlet streams:

(a) EPA Method 25 to determine VOC concentration;
(b) EPA Method 1 or 1A for sample and velocity traverses;
(c) EPA Method 2, 2A, 2C, or 2D for velocity and volumetric flow rates;
(d) EPA Method 3 for gas analysis;
(e) EPA Method 4 for stack gas moisture.

Three runs of EPA Method 25 should be made for each stream. The EPA Method 25 results for both streams may be adjusted by the result generated by running a blank (zero air or nitrogen) stream through the sampling train. (No individual result may be adjusted below zero.) The average of the results for each stream should be used in the equation below.

The EPA Method 2, 2A, 2C, or 2D should be run at least twice for each stream. The average of the results for each stream should be used in the equation below. The EPA Methods 3 and 4 should be performed, as applicable, for each run of EPA Method 2, 2A, 2C, or 2D.

The efficiency of the incinerator controlling emissions from bake oven M is equal to:

$$CDE(M) = 1 - \frac{\text{AVG CONC OF OUTLET} * \text{AVG AIRFLOW OUTLET}}{\text{AVG CONC OF INLET} * \text{AVG AIRFLOW INLET}}$$

23 - DELETED

24 - ACCOUNTING FOR CAPTURED PURGED COATING

At the option of the owner/operator, the coating collected by a purge capture system may be subtracted from the amount of each coating used each day. To do this, records must be kept of the number of purge cycles for each coating each day and the standard amount of each coating captured in a purge cycle. The standard amount of coating captured may be established by direct measurement or by calculation of the volume of as sprayed coating in the line(s) being purged.

The total volume of a coating that is captured by the purge capture system on a particular day is:

TCP(I,N) = CP(I) * NPURGE(I,N)

25- RECORDS OF WITHDRAWALS OF COATING FROM MIX TANKS OR CIRCULATING SYSTEMS

If the owner/operator elects to deduct from topcoat usage any quantity of coating that is not consumed in the topcoat operation, then the following documentation is required.

Records must be kept of each withdrawal of coating from mix tanks or circulating system. Withdrawals include discrete removal of coating from the mix tanks or circulating system in ways other than spraying or purging, and coating continuously supplied through the circulating system to operations other than topcoat. Examples of the first type of withdrawal are coating removed for use in final off-line repair or because of quality considerations. An example of the second type of withdrawal is coating supplied through the circulating system to a fascia coating or wheel coating operation.

The records for each coating must include the date of each discrete withdrawal and the volume of coating withdrawn. A sample record is provided in Figure 11. Continuous withdrawals must be accounted for either by establishing standard values for the volume of coating sprayed per part outside of topcoat (e.g. fascia or wheel) or by extending the daily and monthly vehicle coating summaries to include the coating done outside of the topcoat operation.

If the owner/operator chooses not to document withdrawals of topcoat materials not consumed in the topcoat operation, then the quantity of such withdrawals may not be excluded from the calculation of daily topcoat emission rate.

26 - NOTES ON ALTERNATE WEIGHTING FACTORS

The weighting factors presented earlier in this procedure are based on the square footage coated on each vehicle with each coating in each booth. These factors should give an accurate weighting of individual transfer efficiency and bake oven control device VOC loading values in most cases.

If a source owner or operator desires, weighting factors based on the square feet - mils (i.e. surface area coated times dry film build) coated on each vehicle with each coating in each booth may be used. Such weighting factors could be slightly more accurate than weighting factors based solely on square footage.

In cases where there is a separate "interior" color booth in which coating is applied to edges and interior surfaces at a significantly lower dry film build than coating is applied to exterior surfaces in the main color booth, it may be to the sources' advantage to use weighting factors based on square feet - mils. In cases where "interior" coating is done in the main color booth, it is probably to the owner or operator's advantage to use weighting factors based only on square feet coated.

Weighting factors based on square feet - mils should not be used in Sections 27 and 29. Weighting factors based on square footage coated should be used in Sections 27 and 29.

27 - NOTES ON USING COMBINED

BASECOAT/CLEARCOAT TRANSFER EFFICIENCY TEST RESULTS

As noted in the Transfer Efficiency Test Procedure (Sections 18 and 19), some transfer efficiency tests may result in a measured transfer efficiency value for BC/CC combined, rather than individual values for BC and CC. In this case the measured values may be directly used for each BC. That is, for each BC, BTE(I,M) should be set equal to the measured transfer efficiency value for BC(I)/CC. For CC, BTE(CC, M) must be calculated each day from the daily weighted average of the measured transfer efficiency values for each BC/CC combination weighted by the fraction of the total square footage coated in booth M on day N with each BC. These weighting factors are the coating column fractions in the daily vehicle coating summary. On day N:

$$BTE(CC, M) = \frac{\underset{ALL\ BC}{SUM}\ CFRAC(I,M,N)}{\underset{ALL\ BC}{SUM}\ [CFRAC(I,M,N)/BTE(I,M)]}$$

A sample calculation is presented in Figure 21.

28 - NOTES ON USING TRANSFER EFFICIENCY TEST RESULTS WHEN THE TEST ENVELOPE IS MORE THAN ONE BOOTH LONG

Some transfer efficiency tests may span more than one spray booth. For example, an interior color booth and main color booth may be covered by a single test. If a transfer efficiency test spans booths M and M', then BTE(I,M) and BTE(I,M') must be set equal to the test result for coating I.

29 - NOTES ON USING COMBINED BASECOAT/CLEARCOAT BAKE OVEN

CONTROL DEVICE VOC LOADING DATA

As noted in the Test Procedure for Determining Bake Oven Exhaust Control Device VOC Loading for Specific Coatings, at the owner/operator option, control device VOC loading values may be determined for BC/CC combined, rather than individual values for BC and CC. In this case, for each basecoat, set CDL(I,M) equal to the measured value for that basecoat/clearcoat. For clearcoat, CDL(CC,M) must be calculated each day. CDL(CC,M) should be set equal to the daily weighted average of the measured control device VOC loading values for each basecoat/clearcoat weighted by the fraction of the total square footage coated in booth M on day N with each basecoat. These are the coating column fractions in the daily vehicle coating summary.

$$CDL(CC,M) = \frac{\underset{\text{ALL BC}}{\text{SUM}} [CDL(I,M) * CFRAC(I,M,N)]}{\underset{\text{ALL BC}}{\text{SUM}} [CFRAC(I,M,N)]}$$

A sample calculation is presented in Figure 8.

As noted in the section on Daily Individual Bake Oven Control Device VOC Loading Values (Section 14), as an alternative, TCDL(M,N) can be set equal to the minimum value measured by the test procedure. In this case there would be no need to calculate a separate value, CDL(CC,M), for clearcoat.

30 - NOTES ON ACCOUNTING FOR DILUTION SOLVENT ADDED BY THE COATING MANUFACTURER AT A SATELLITE PAINT PLANT

Some assembly plants have nearby satellite paint plants at which the coating manufacturer may add dilution solvent or other ingredients to coatings before delivering them to the assembly plant. Satellite paint plants frequently deliver coatings to the assembly plant in ready-to-spray condition (i.e. no solvent additions are made at the assembly plant) on a just-in-time basis.

The satellite paint plant must maintain records of all dilution solvent additions and all other additions made before shipping coatings to the assembly plant. The satellite paint plant must also adjust the analytical VOC content, formulation solvent content and volume solids content of each container (drum, tote, etc.) of coating shipped to the assembly plant to account for these additions. These adjustments should be made using calculations similar to those presented in Sections 10, 11 and 12.

31 - CALCULATING FORMULATION WEIGHT FRACTION SOLVENT AS OF SUPPLIED COATING

This section describes the calculations which should be performed to determine the formulation weight fraction solvent content of an as supplied coating. These calculations should be based on the coating manufacturer's formula and batch production records at a point in the coating manufacturing process at and beyond which coating ingredients are mixed or blended only. (No more chemical reactions should take place in the coating manufacturing process.) All materials added before packaging for shipment (e.g., for tinting and adjusting to receive quality control approval) should be included in these calculations.

1 - Set B equal to the number of ingredients in the formula for coating I, including those ingredients added to tint or adjust the coating.

2 - Set WT(I,J,A) equal to the pounds of ingredient A added to the batch of coating I used in addition J. [For ingredients added by volume, WT(I,J,A) can be calculated by multiplying the volume (gallons) added by the density (pounds per gallon) of the ingredient as in Steps 2 through 4 of Section 33. Density should be determined using ASTM D-1475. For dry materials, actual density, not bulk density, should be determined analytically. The density analysis may be performed by the supplier of the ingredient.]

3 - For each ingredient in the formula, determine the weight fraction volatiles, WTVOL (I,J,A), using the appropriate portion of ASTM D-2832. (Note that weight fraction volatiles equals 1 minus weight fraction nonvolatiles.) This information may be provided to the coating manufacturer by the supplier of the ingredient.

4 - For each ingredient in the formula which contains water or exempt* solvents, determine the weight fraction water or exempt solvent, WTNR(I,J,A). This information may be provided to the coating manufacturer by the supplier of the ingredient.

5 - For each ingredient in the formula, calculate the weight fraction solvent, WTSOLV(I,J,A), using the following equation:

$$WTSOLV(I,J,A) = WTVOL(I,J,A) - WTNR(I,J,A)$$

6 - Calculate the formulation weight fraction solvent content of the as supplied coating WTFRSV(I,J), using the following equation:

$$WTFRSV(I,J) = \frac{\sum_{A=1}^{B} WTSOLV(I,J,A) * WT(I,J,A)}{\sum_{A=1}^{B} WT(I,J,A)}$$

*Exempt solvent means organic solvents which are determined by the Administrator of the EPA to have negligible photochemical reactivity and which are similarly recognized in the particular regulation with which compliance is being determined using this procedure.

32 - CALCULATING FORMULATION SOLVENT CONTENT OF AS SUPPLIED COATING

This section describes the calculations which should be performed to determine the formulation solvent content, CF(I,J), of an as supplied coating.

1 - Determine the density of the coating, DENS(I,J), using ASTM D-1475. (Note, this is the same density analysis made in determining the analytical VOC content of the coating.)

2 - Calculate the formulation solvent content, CF(I,J), of the as supplied coating using the following equation:

$$CF(I,J) = WTFRSV(I,J) * DENS(I,J)$$

33 - FORMULATION VOLUME SOLIDS CONTENT OF AS SUPPLIED COATING

This section describes the calculations which should be performed to determine the formulation volume solids content of an as supplied coating. These calculations should be based on the coating manufacturer's formula and batch production records at a point in the coating manufacturing process at and beyond which coating ingredients are mixed or blended only. (No more chemical reactions should take place in the coating manufacturing process.) All materials added before packaging for shipment (e.g., for tinting or adjusting to receive quality control approval) should be included in these calculations.

1 - Set B equal to the number of ingredients in the formula for coating I, including those ingredients added to tint or adjust the coating.

2 - For ingredients added by weight, set WT(I,J,A) equal to the pounds of ingredient A added to the batch of coating I used in addition J. For ingredients added by volume, set VOL(I,J,A) equal to the gallons of ingredient A added to the batch of coating I used in addition J.

3 - Determine the density, DEN(I,J,A), of each ingredient A in the batch of coating I used in addition J using ASTM D-1475. For dry materials, actual density, not bulk density, should be determined analytically. The units for DEN(I,J,A) are pounds per gallon. This information may be provided to the coating manufacturer by the supplier of the ingredient.

4 - For ingredients added by weight, calculate the volume (gallons) of ingredient A added to the batch of coating I used in addition J using the following equation:

$$VOL(I,J,A) = WT(I,J,A) / DEN(I,J,A)$$

For ingredients added by volume, calculate the weight (pounds) of ingredient A added to the batch of coating I used in addition J using the following equation:

$$WT(I,J,A) = DEN(I,J,A) * VOL(I,J,A)$$

5 - For each ingredient in the formula, determine the weight fraction volatiles, WTVOL(I,J,A), using the appropriate portion of ASTM D-2832. (Note that weight fraction volatiles equals 1 minus fraction nonvolatiles.) This information may be provided to the coating manufacturer by the supplier of the ingredient.

6 - For each ingredient in the formula, determine the density of the volatiles in that ingredient, DVOL(I,J,A). The units for DVOL(I,J,A) are pounds per gallon. This information may be provided to the coating manufacturer by the supplier of the ingredient.

7 - For each ingredient in the formula, determine the volume fraction solids, VFS (I,J,A) using the following equation:

$$VFS(I,J,A) = 1 - \frac{WTVOL(I,J,A) * WT(I,J,A)}{DVOL(I,J,A) * VOL(I,J,A)}$$

8 - As an alternative to steps 5 through 7, the volume fraction solids of an ingredient may be determined directly. This would be particularly useful for ingredients which contain no solids (e.g., solvents) or no volatiles (e.g., dry solids). Ingredients which are thought to be pure liquid resins should be checked as in step 5 to ensure that there are no volatiles (e.g., low molecular weight oligimers) present before concluding that they contain only solids. This information may be provided to the coating manufacturer by the supplier of the ingredient.

9 - Calculate the formulation volume solids content of the as supplied coating using the following equation:

$$VS(I,J) = \frac{\sum_{A=1}^{B} VFS(I,J,A) * VOL(I,J,A)}{\sum_{A=1}^{B} VOL(I,J,A)}$$

34 - RECORDKEEPING REQUIREMENTS

The source owner or operator must maintain at the source, for the time period required by the applicable regulation, all records and calculations used to determine daily VOC emissions from each topcoat operation.

35 - NOTES ON USING THIS PROTOCOL TO DETERMINE THE DAILY VOC EMISSION RATE OF AUTOMOBILE AND LIGHT-DUTY TRUCK SURFACER OPERATIONS

This section reserved for instructions on how to use this protocol to determine the daily VOC emission rate of automobile and light-duty truck surfacer operations.

APPENDIX A

EXAMPLE CALCULATIONS

Figure 1

Spray Booth and Bake Oven Layout for Example Calculations

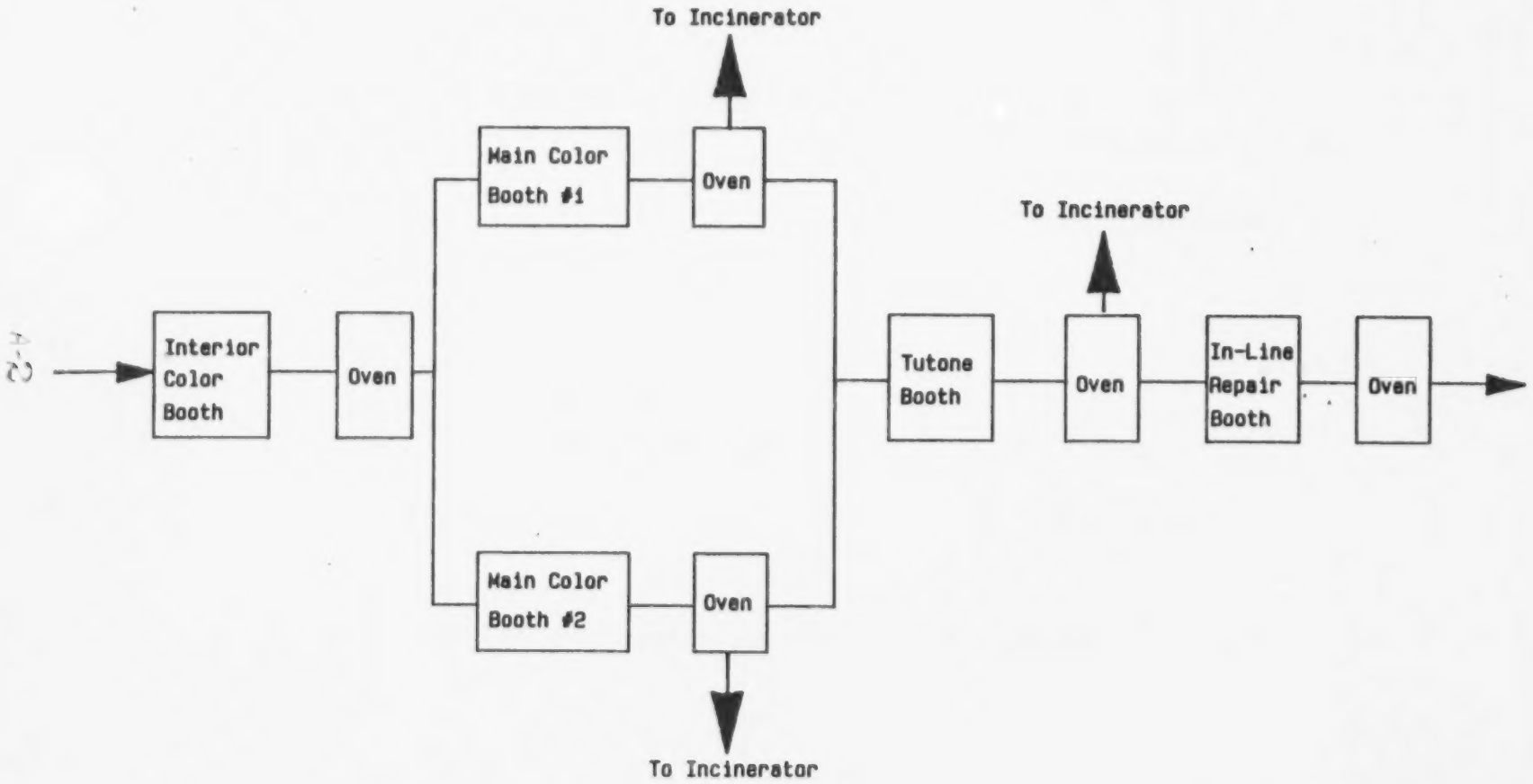

FIGURE 2

Notes on sample coating line and sample calculations

Coatings Used

Red	(R) straight shade
White	(W) base coat
Blue Metallic	(B) base coat
Clear Coat	(CC)

Body Styles

2-door
4-door

Tutones

About half of the red vehicles receive B/CC accent color in tutone booth.

Daily Production

About 800 vehicles per day

The daily calculations are presented for July 14, 19XX. The index (14) indicates the 14th day of the month.

FIGURE 3

(See Section 16)

Individual Vehicle Coating Records - July 14, 19XX

Vehicle ID/Style	Interior		Main Color #1			Main Color #2			Tutone			In-Line Repair		
	Color	Sq Ft	Color	Sq Ft	CC Sq Ft	Color	Sq Ft	CC Sq Ft	Color	Sq Ft	CC Sq Ft	Color	Sq Ft	CC Sq Ft
07140001-2	R	42.0	R	150.0	150.0									
07140002-2	W	42.0				W	150.0	150.0	B	70.0	70.0			
07140003-2	B	42.0	B	150.0	150.0									
07140004-4	B	44.0				B	160.0	160.0				B	25.0	25.0
.														
.														
.														
.														
.														
07140780-4	R	44.0				R	160.0	160.0	B	70.0	70.0			

FIGURE 4

(See Section 16)

Daily Vehicle Coating Summary - July 14, 19XX

Coating	Interior	Main #1	Main #2	Tutone	Repair	Total
R	17200(.213) (.513)	46500(.575) (.625)	15500(.192) (.147)	0(.000) (.000)	1600(.020) (.317)	80800(1.000) (.328)
W	10320(.213) (.308)	6200(.128) (.083)	31000(.639) (.294)	0(.000) (.000)	960(.020) (.190)	48480(1.000) (.197)
B	6020(.142) (.179)	7750(.182) (.104)	13950(.328) (.132)	14000(.330) (.500)	760(.018) (.151)	42480(1.000) (.172)
CC	0(.000) (.000)	13950(.187) (.188)	44950(.602) (.426)	14000(.188) (.500)	1720(.023) (.341)	74620(1.000) (.303)
Total	33540(.136) (1.000)	74400(.302) (1.000)	105400(.428) (1.000)	28000(.114) (1.000)	5040(.020) (1.000)	246380(1.000) (1.000)

Square Feet Coated (Row Fraction)
(Column Fraction)

FIGURE 5

(See Section 15)

Monthly Vehicle Coating Summary - July 19XX

Coating	Square Feet Coated
R	1,535,200
W	1,018,080
B	849,600
CC	1,641,640

FIGURE 6

(See Section 18)

Transfer Efficiency Test Results

Coating	Main Color TE
R	.68
W	.57
B	.47
CC	.74

Each coating was tested because each coating is processed differently. CC was tested separately. See Figure 21 for example with CC tested together with BC.

FIGURE 7

(See Section 20)

Untested Transfer Efficiencies

Coating	Interior	Tutone	Repair
R	.40	NA	.40
W	.40	NA	.40
B	.40	.40	.40
CC	NA	.55	.55

All interior coating is done with air spray. Straight shades and basecoats are applied by air spray in tutone and repair booths. Clearcoat is applied by electrostatic spray in tutone and repair booths.

FIGURE 8

(See Section 21)

Bake Oven Exhaust Control Device VOC Loading - Panel Test Results

Coating	Main Color	Tutone
R	2.0	NA
W/CC	2.3	NA
B/CC	2.1	2.0

Calculation of separate value for main color CC for July 14, 19XX. (See section 29.)

Main #1

$$\frac{(2.3)(.083) + (2.1)(.104)}{.083 + .104} = 2.2$$

Main #2

$$\frac{(2.3)(.294) + (2.1)(.132)}{.294 + .132} = 2.2$$

FIGURE 9

(See Section 22)

Bake Oven Exhaust Incinerator Efficiency Test Results

Main #1	96%
Main #2	96%
Tutone	94%

FIGURE 10

(See Section 13)

Daily Weighted TE for July 14, 19XX

$$R \quad \frac{1}{\frac{.213}{.40} + \frac{.575}{.68} + \frac{.192}{.68} + \frac{.020}{.40}} = \frac{1}{1.710} = .585$$

$$W \quad \frac{1}{\frac{.213}{.40} + \frac{.128}{.57} + \frac{.639}{.57} + \frac{.020}{.40}} = \frac{1}{1.928} = .519$$

$$B \quad \frac{1}{\frac{.142}{.40} + \frac{.182}{.47} + \frac{.328}{.47} + \frac{.330}{.40} + \frac{.018}{.40}} = \frac{1}{2.31} = .433$$

$$CC \quad \frac{1}{\frac{.187}{.74} + \frac{.602}{.74} + \frac{.188}{.55} + \frac{.023}{.55}} = \frac{1}{1.45} = .690$$

FIGURE 11

(See Section 10, 11, 12 and 25)

Monthly Additions for Red - July 19XX

Start 1510
End 1210

		Coating				Diluent	
Date	Batch	Gal PADD	Formula CF	Analytical CA	Formula Vol Solids VS	Gal RADD	Density RD
7/1	A	1000	3.70	4.00	.47	50	6.8
7/3	A	600	3.70	4.00	.47		
7/7	A	850	3.70	4.00	.47	60	6.8
7/9	B	1000	3.60	3.90	.48		
7/12	B	850	3.60	3.90	.48	60	6.8
7/15	C	800	3.80	4.20	.46		
7/18	C	700	3.80	4.20	.46	60	6.8
7/21	C	1000	3.80	4.20	.46		
7/24	D	900	3.60	3.90	.48	50	6.8
7/28	D	1000	3.60	3.90	.48		
7/30	D	1000	3.60	3.90	.48	60	6.8
		9700				340	

Withdrawals for Red - July 19XX.

Date	Gal	Destination
7/12	50	Final repair

FIGURE 12

(See Section 17)

Monthly Coating Usage - July 19XX

Coating	Gallons	Formula (RCF)	Analytical* (RCA)	Vol Solids (RVS)
R	10290	3.78	4.10	.456
W	3500	4.11	4.32	.423
B	3400	4.49	4.72	.359
CC	4200	3.31	3.65	.527

For red, monthly usage = 1510 - 1210 + 9700 + 340 - 50 = 10290
The data for this calculation came from Figure 11.

* See Figure 13 for sample calculation.

FIGURE 13

(See Section 10)

Analytical VOC Content of as Applied Red Coating - July 19XX

Coating Additions

Gallons PADD(I,J)	x	Test VOC CA(I,J)	=	Total VOC
1000		4.00		4000
600		4.00		2400
850		4.00		3400
1000		3.90		3900
850		3.90		3315
800		4.20		3360
700		4.20		2940
1000		4.20		4200
900		3.90		3510
1000		3.90		3900
1000		3.90		3900
9700				38825

Diluent Additions

Gallons PADD(I,K)	x	Density RD(I,K)	=	Total VOC
50		6.8		340
60		6.8		408
60		6.8		408
60		6.8		408
50		6.8		340
60		6.8		480
340				2312

$$RCA(I) = \frac{38825 + 2312}{9700 + 340} = 4.10$$

FIGURE 14

(See Section 8)

Daily Coating Usage - July 14, 19XX

Coating I	Month's Usage GMON(I)	x	Day's Sq. Ft. DAYSQFT(I,14)	/	Month's Sq. Ft. MONSQFT(I)	=	Day's Usage GDAY(I,14)
R	10290		80800		1535200		541.6
W	3500		48480		1018080		166.7
B	3400		42480		849600		170.0
CC	4200		74620		1641640		190.9

FIGURE 15

(See Section 9)

VOC Generated per Gallon of as Applied Coating Used - July 14, 19XX

Coating I	Formula RCF(I)	x	1-TE	+	Analytical RCA(I)	x	TE TE(I,14)	=	VOC Gen RCV(I,14)
R	3.78		.415		4.10		.585		3.97
W	4.11		.481		4.32		.519		4.22
B	4.49		.567		4.72		.433		4.59
CC	3.31		.310		3.65		.690		3.55

FIGURE 16

(See Section 5)

Total Daily VOC Generated - July 14, 19XX

Coating I	Gallons GDAY(I,M)	x	VOC/Gal RCV(I,14)	=	VOC Generated (Pounds)
R	541.6		3.97		2150.2
W	166.7		4.22		703.5
B	170.7		4.59		780.3
CC	190.9		3.55		677.7
Total					4311.7 = DVG(14)

FIGURE 17

(See Section 6)

Total Daily Volume Solids Deposited - July 14, 19XX

Coating I	Gallons GDAY(I,M)	x	Vol Solids RVS(I)	x	Daily TE TE(I,14)	=	Solids Dep (Gallons)
R	541.6		.456		.585		144.5
W	166.7		.423		.519		36.6
B	170.0		.359		.433		26.4
CC	190.9		.527		.690		69.4
Total							276.9 = DSD(14)

FIGURE 18

(See Section 14)

Daily Individual Bake Oven Exhaust Control Device VOC Loading Values

Main #1 2.0(.625) + 2.3(.083) + 2.1(.104) + 2.2(.188) = 2.07

Main #2 2.0(.147) + 2.3(.294) + 2.1(.132) + 2.2(.426) = 2.19

Tutone = 2.00

FIGURE 19

(See Section 7)

Total Daily Bake Oven Exhaust Control Credit - July 14, 1988

Booth/Oven	VOC Loading TCDL(M,14)	Control Eff CDE(M)	Wtg Factor BRFRAC(M,14)	Control Credit
Main #1	2.07	.96	.302	.60
Main #2	2.19	.96	.428	.90
Tutone	2.00	.94	.114	.21
Total				1.71 = DCC(14)

FIGURE 20

(See Section 4)

Daily VOC Emission Rate Calculation - July 14, 19XX

DER(14) = [DVG(14)/DSD(14)] - DCC(14)

= [4311.7/276.9] - 1.71

= 13.86 pounds VOC per gallon solids deposited

FIGURE 21

(See Section 27)

Calculating CC TE from combined BC/CC Transfer Efficiency Test Results

TE test results

W/CC .640

B/CC .580

CC TE for July 14, 19XX

Main Color Booth #1

$$BTE(CC, Main\ 1) = \frac{.083 + .104}{\frac{.083}{.640} + \frac{.104}{.580}} = \frac{.187}{.309} = .605$$

Main Color Booth #2

$$BTE(CC, Main\ 2) = \frac{.294 + .132}{\frac{.294}{.640} + \frac{.132}{.580}} = \frac{.426}{.687} = .620$$

FIGURE 22

(See Section 16)

Sample Calculation of Equivalent Vehicles

Vehicle	Process Step	Square Feet Coated	Equivalent Vehicles
2-Door Sedan	Main Color	184	0.92
	Tutone	10	0.05
4-Door Sedan	Main Color	200	1.00
	Tutone	12	0.06
Station Wagon	Main Color	229	1.15
	Tutone	17	0.09

In this sample, the "base vehicle" is the 4-Door Sedan Main Color step. (200 square feet coated is equated to 1.00 equivalent vehicle.)

FIGURE 23

(See Section 16)

Sample Calculation of 4 Percent Standard Daily Repair Rate

Using data for red (R) coating in Figure 4:

Booth	Square Feet Coated
Interior	17200
Main #1	46500
Main #2	15500
Total (excluding repair)	79200

Repair Square Feet Coated = 79200 * 0.04 = 3168

Total (including repair) = 79200 + 3168 = 82368

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FIGURE 24

(See Section 19)

Pilot Line TE Test Data Validation

	In-Plant	Pilot
Wt solids sprayed/vehicle	2.80 lbs	3.10 lbs
Average Class I film build	2.20 mils	2.00 mils
Average Class II film build	1.30 mils	1.50 mils
Overall average film build	1.90 mils	1.83 mils

Solids sprayed test $\frac{3.10 - 2.80}{3.10} * 100 = +9.7\%$ OK

Overall film build change $\frac{1.83 - 1.90}{1.90} * 100 = -3.7\%$ OK

Consistency of solids sprayed and overall film build $ABS[9.7 - (-3.7)] = 13.4 \leq 20$ OK

FIGURE 25

(See Section 19)

Calculation of Pilot Line TE

Weight solids sprayed per vehicle (pilot) 3.10 lbs

Weight solids deposited per vehicle (pilot) 1.98 lbs

$$\text{Pilot TE} = \frac{1.98}{3.10} = 0.64$$

ADDED 11/88

FIGURE 26

(See Section 19)

Calculation of Adjusted Pilot Line TE

Weight solids sprayed per vehicle (pilot) 3.10 lbs

Weight solids sprayed per vehicle (plant) 2.80 lbs

Overall average dry film build (pilot) 1.83 mils

Overall average dry film build (plant) 1.90 mils

Pilot TE = 0.64

$$\text{Adjusted Pilot TE} = 0.64 * \frac{3.10}{2.80} * \frac{1.90}{1.83} = 0.74$$

ADDED 11/88

FIGURE 27

(See Section 19)

Annual Revalidation and Readjustment of Pilot Line TE Test Data

	New In-Plant	Old Pilot
Wt solids sprayed/vehicle	3.20 lbs	3.10 lbs
Average Class I film build	2.0 mils	2.0 mils
Average Class II film build	1.3 mils	1.5 mils
Overall average film build	1.77 mils	1.83 mils
Solids sprayed test	$\frac{3.10 - 3.20}{3.20} * 100 = -3.1\%$ OK	
Overall film build change	$\frac{1.83 - 1.77}{1.77} * 100 = +3.4\%$ OK	
Consistency of solids sprayed and overall film build	ABS(-3.1 - 3.4) = 6.7 $\leq$ 20 OK	

New Adjusted Pilot TE = $0.64 * \frac{3.10}{3.20} * \frac{1.77}{1.83}$

= 0.60

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FIGURE 28

(See Section 19)

Determination of Required Number of Dry Film Build Measurements for Vehicle with Plastic Parts

	Square Footage Coated		
	"Magnetic" (Steel)	"Non-Magnetic" (Plastic)	Total
Class I	110	40	150
Class II	70	10	80
Total	180	50	230

Percent non-maynetic area $\frac{50}{230} * 100 = 22\% < 25\%$

Therefore, dry film build measurements are not needed on non-magnetic areas.

The required number of before and after measurements per vehicle are:

150 on 110 square feet of magnetic Class I area

160 on 70 square feet of maynetic Class II area (160 = 80 * 2)

FIGURE 28 (Continued)

Square Footage Coated

	"Magnetic" (Steel)	"Non-Magnetic" (Plastic)	Total
Class I	90	60	150
Class II	70	10	80
Total	160	70	230

Percent non-magnetic area $\frac{70}{230} * 100 = 30\% > 25\%$

Therefore, dry film build measurements are required on non-magnetic areas.

The required number of before and after measurements per vehicle are:

150 on 150 square feet of Class I area

160 on 80 square feet of Class II area

ADDED 11/88

FIGURE 29

(See Section 19)

Calculation of Overall Average Dry Film Build

	Square Feet Coated
Class I	150
Class II	80
Total	230

Overall average dry film build equals:

$$\frac{\text{average Class I dry film build} * 150}{230} + \frac{\text{average Class II dry film build} * 80}{230}$$

APPENDIX B

SUMMARY OF ADDITIONS AND REVISIONS TO JUNE 10, 1988 VERSION OF PROTOCOL

Revised Section 18 added November 1988.

Scope moved from page 18-2 to 18-1.

New language in paragraph B on page 18-2.

No changes on page 18-3.

New item 6 at top of page 18-4.

One line moved from page 18-4 to 18-5, and one sentence moved from page 18-6 to 18-5.

New language in Frequency of Certification on page 18-6.

New Section 19 added November 1988.

Adds pilot line transfer efficiency test procedure to protocol.

Revised page 33-3 added November 1988.

Adds denominator to equation in Part 9.

New Figures 24 - 29 added November 1988.

These figures illustrate new Section 19 also added November 1988.

New page iii added December 1988.

Adds Appendix A (Example Calculations)
and Appendix B (Summary of Additions and Changes) to table of contents. The example calculations were previously in a separately bound volume.

Revised page 1-2 added December 1988.

New language in first sentence to indicate that example calculations are in Appendix A.

Adds paragraph about agency review of owner/operator selected conditions and parameters.

Adds paragraph which notes that changes and additions from original June 10, 1988, version are summarized in Appendix B.